ABSORPTION BY THE ROOTS

Plant physiology:- is the branch of biology which deals with the life functions or metabolism of the plant.

ABSORPTION BY THE ROOTS

The roots not only fix the plant in the soil giving it support but the most important and life supporting function of the roots is to absorb water and mineral nutrients from the soil and conduct them into the stem for supply to the leaves, flowers, fruits, etc.

NEED OF WATER AND MINERALS FOR PLANTS

Besides being a constituent of protoplasm, water is needed inside the plant body for four purposes: photosynthesis, transpiration, transportation and mechanical stiffness.

1. Photosynthesis: Water is used up in the green leaves as a raw material in the synthesis of glucose.

2. Transpiration: A large quantity of water gets evaporated as water vapour during transpiration, for cooling in hot weather, for producing a suction force, etc.

3. Transportation: Transportation of substances in water solution from the roots upward into the shoot (mineral salts) or from leaves to other parts (sugar, etc).

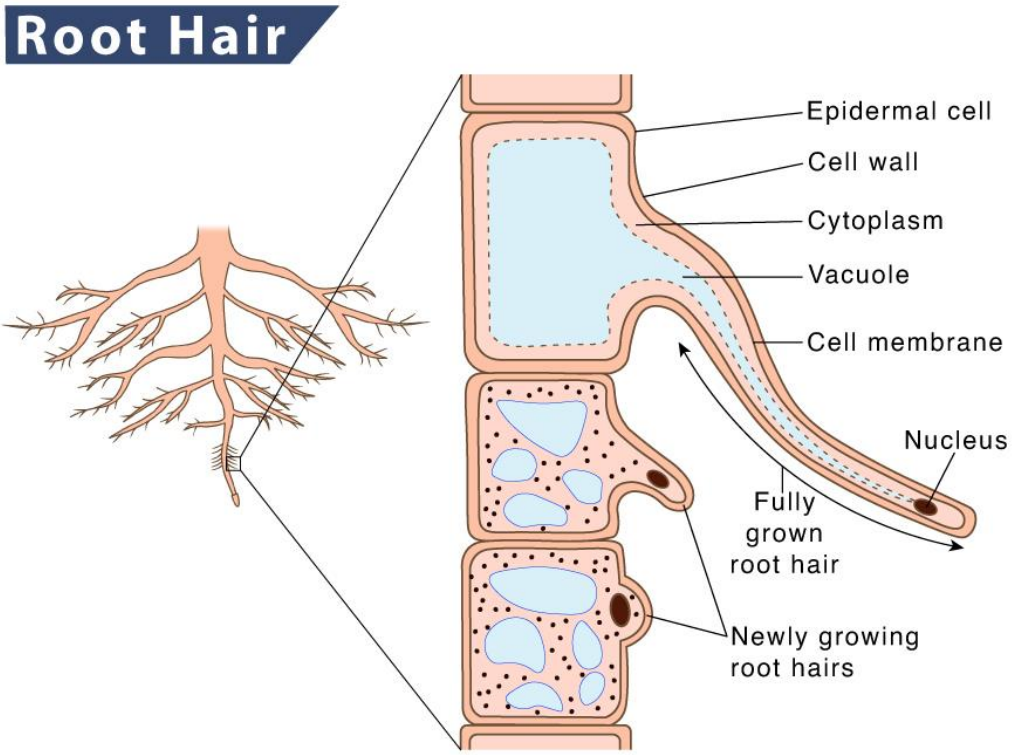
4. Mechanical stiffness: Water provides turgidity (fully distended condition), which is necessary for the stiffness of plant tissues.

CHARACTERISTICS OF ROOTS FOR ABSORBING WATER

The ability of the roots to draw water from the soil is dependent on three characteristics:

(i) Surface area of roots is enormous:- If even a small garden plant such as balsam, when gently uprooted from the soil, shows thick a bunch of rootlets.

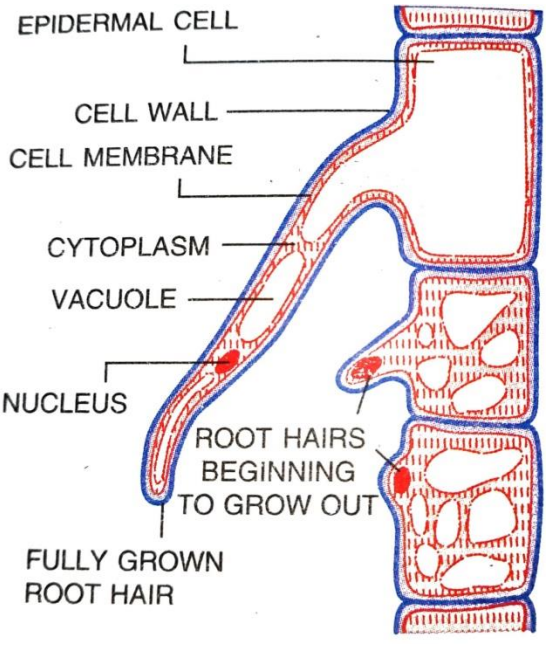
(ii) Root hairs contain cell sap, of a higher concentration than that of the surrounding water:-



Root hairs are the extensions of the outer (epidermal) cells of the root. They also contain large vacuoles filled with a solution called cell sap. Some salts are dissolved in it and the cell sap, therefore, usually has a concentration higher than that of the surrounding water.

(iii) Root hairs have thin walls: Like all plant cells, root hairs also have two outer layers a cell wall and a cell membrane.

- The cell wall is thin and permeable. It allows the movement of water molecules and dissolved substances freely in and out of the cell.



The cell membrane is very thin, and semi permeable, which means that it allows water molecules to pass through, but not the larger molecules of the dissolved salts. The secret of the absorption of water from the soil by the roots lies mainly in this characteristic.

ABSORPTION AND CONDUCTION OF WATER AND MINERALS

The entire mechanism of absorbing water and minerals from the soil by the roots, its movement through the thickness of the root and subsequently its upward conduction through the stem, is the result of five main phenomena:

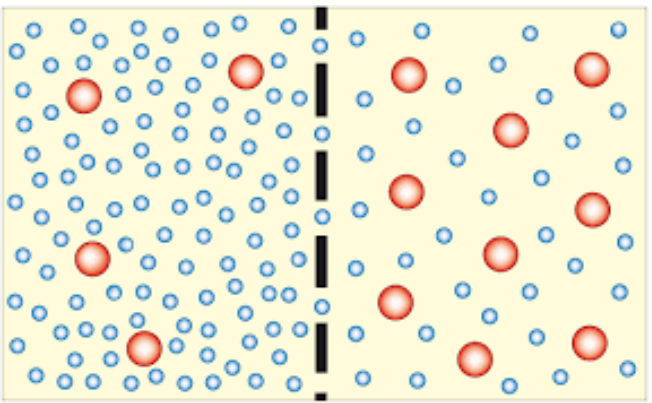
1. Imbibition
2. Diffusion
3. Osmosis
4. Active transport
5. Turgidity and Flaccidity

1. Imbibition

Imbibition is a phenomenon by which the living or dead plant cells absorb water by surface attraction.Ex: Dry seeds, wooden doors swell up during rain.

2. Diffusion

Diffusion is the free movement of molecules of a substance (solute or solvent, gas, liquid) from the region of their higher concentration to the region of their lower concentration when the two are in a direct contact.Ex: Pottasium permanganate dissolves evenly throughout the water.



3. Osmosis and osmotic pressure

A. Osmosis

Osmosis is the movement of water molecules from their region of higher concentration to their region of lower concentration through a semi permeable membrane

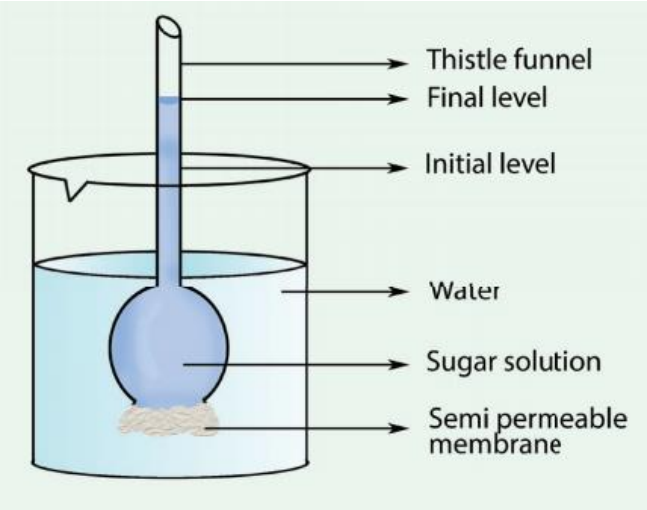
ENDOSMOSIS:- It is the inward diffusion of water through a semi permeable membrane when the surrounding solution is less concentrated. This tends to swell up the cell.

EXOSMOSIS :- It is the outward diffusion of water through a semi-permeable membrane when the surrounding solution is more concentrated. This tends to cause shrinkage of the cell.

Semipermeable membrane: it allows the passage of molecules selectively.

Some Semipermeable membranes: visking bag, cellophane paper

What happen when Rubber sheet and muslin cloth instead of cellophane as a barrier



- The rubber sheet is impermeable and would not allow the water molecules from the beaker to cross over to the other side.
- In the second case, the meshes or pores of the muslin cloth are so large that they would not hold back even the sugar molecules, and the entire sugar solution would flow down to a common level due to gravity. The muslin cloth is, therefore, freely permeable for sugar solution.

How long can osmosis continue?

Theoretically, osmosis should continue until the concentration of water molecules becomes equal on both sides of the membrane. Such an increase in the height and weight of the rising column reduces further osmosis. In this state of equilibrium, the water molecules from the beaker tend to force upwards through the membrane, but the weight or the pressure from above holds them downwards.

B. OSMOTIC PRESSURE

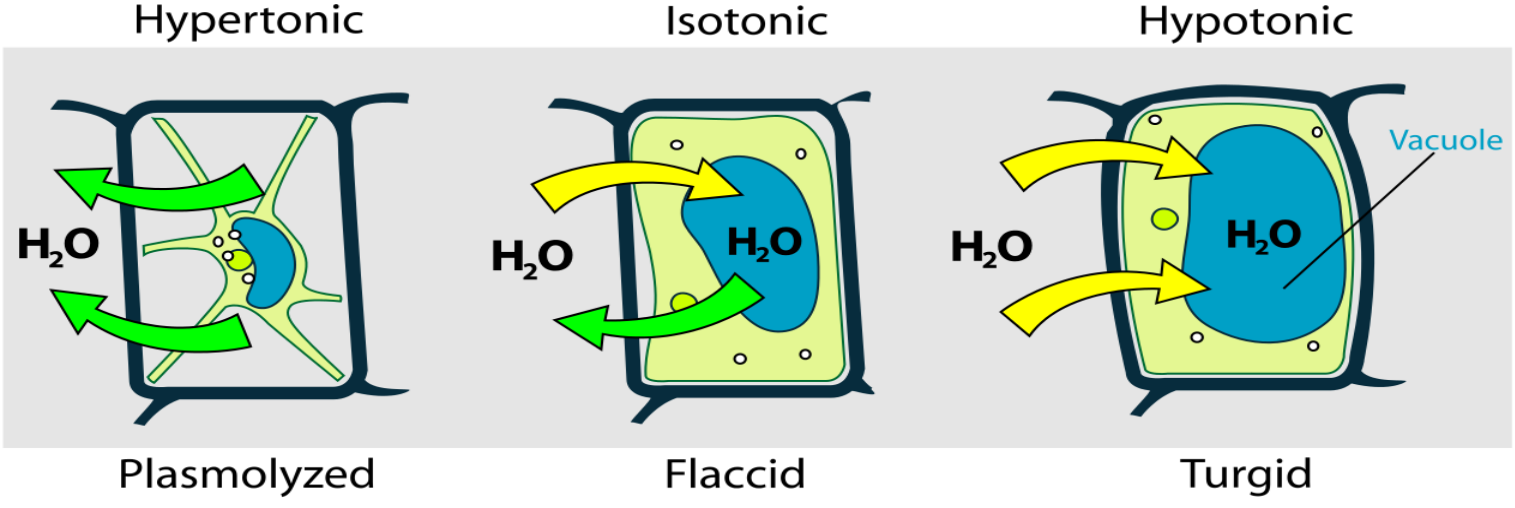
Osmotic pressure is the minimum pressure that must be exerted to prevent the passage of the pure solvent into the solution when the two are separated by a semi-permeable membrane.

TONICITY:- Relative concentration of the solutions that determine the direction and extent of diffusion is called tonicity. Based on it, the solution can be of three types: isotonic, hypotonic and hypertonic solutions.

1. Isotonic:- The relative concentration of water molecules and the solute on either side of the cell membrane is the same.No osmosis

2. Hypotonic:- In this condition, the solution outside the cell has a lower solute concentration than the fluids inside the cell. Cell swells (Endosmosis)

3. Hypertonic:- In this condition, the solution outside the cell has a higher solute concentration than the fluids inside the cell. Cell



shrinks (Exosmosis)

Active Transport

Active transport is the passage of a substance (salt or ion) from its lower to higher concentration through a living cell membrane using energy from the cell.

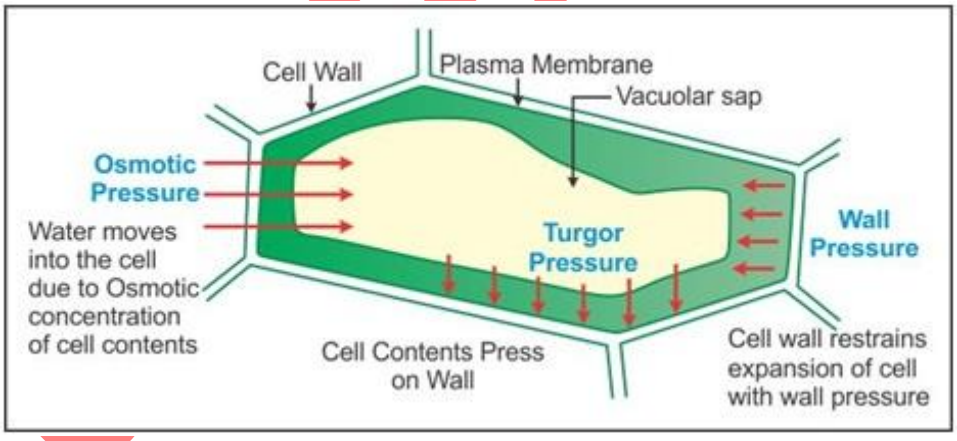
Certain nutrients such as ions of nitrates, sulphates, potassium, zinc, manganese, etc. cannot pass through the cell membrane of the root cells easily so energy is required.

Passive Transport – It is free movement of molecules from HC to LC.

Turgidity and Flaccidity

• When a cell reaches a state where it cannot accommodate any more water, i.e., it is fully distended, it is called turgid and the condition is called turgidity.

• The pressure of the cell contents on the cell wall is called **turgor pressure** and the pressure exerted by the cell wall on the cell content is called **wall pressure**.



Plasmolysis and Flaccidity:-

This shrinkage from the cell wall is called plasmolysis and the cells in this state are said to be limp or flaccid. Flaccidity is the reverse

of turgidity. The recovery or the reversal of plasmolysis is called deplasmolysis.

The terms defined:--

- **Turgidity:-** It is the state of a cell in which the cell wall is rigid and stretched by an increase in the volume of vacuoles due to the absorption of water. The cell is then said to be **turgid.**

- **Plasmolysis:-** It is the contraction of cytoplasm from the cell wall caused due to the withdrawal of water when placed in a strong (hypertonic) solution.

- **Flaccidity:-** It is the condition in which the cell content is shrunken and the cell is no more "tight". The cell is then said to be flaccid.

USES OF TURGIDITY TO PLANTS

1. Turgidity provides rigidity to soft tissues such as the leaves:- When there is not enough water in a leaf, it wilts, i.e., its petiole and lamina become loose and the leaf droops down.Ex : Leaf wilting during hot afternoon

2. Turgor pressure helps to push through the hard ground as in mushrooms and in a seedling: the roots of certain trees have been seen to crack the walls or a concrete floor of an adjoining building.

3. Turgor in root cells builds up root pressure: If you cut a well-watered pot plant a few centimetres above the soil and immediately fix a glass tubing to it by means of a rubber connection, water will start coming out of the cut end of the stem and rise up in the glass tubing.

4. Turgor in the opening and closing of stomata: Their opening and closing depend on the turgidity of guard cells. Each guard cell has a thicker wall on the side facing the stoma and a thin wall on the opposite side. On account of turgor, the guard cells become more arched outwards and the aperture between them widens, thereby opening the stoma.

5. Turgor Movement: The rapid drooping of the leaves of the sensitive plant is an outstanding example of turgor movement. If one of the leaves is touched, even lightly, the leaflets fold up and within 2 to 3 seconds, the entire leaf droops. The base of petiole is called pulvinus.

ROOT PRESSURE

- It is the pressure developed in the roots due to continued inward movement of water through cell-to-cell osmosis which helps in the ascent of cell sap upward through the stem.
- Root pressure is built up due to cell-to-cell osmosis in the root tissue. As one turgid cell presses the next cell, the force of the flow of water increases inward. When water reaches the xylem vessels it enters the pores of their thick walls with considerable force.

Guttation

In certain plants, like tomato, grass, banana or ferns, the root pressure is high enough to force the water all the way through the stem and comes out through the ends of leaf veins. This water apppears as tiny drops along the margins or the tips of the leaves especially in the early mornings. This loss of excessive water is called guttation.

IMPORTANCE OF ROOT HAIRS AND THE UPWARD MOVEMENT OF ABSORBED WATER AND MINERALS

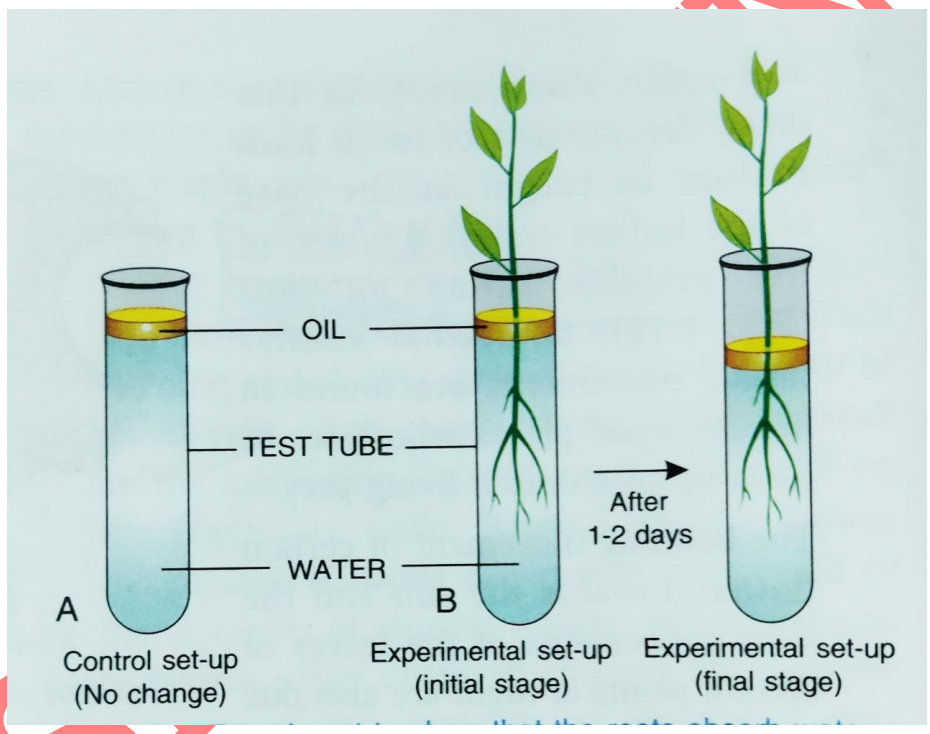
Absorption of water by the root is by means of root hairs. A root hair contains cell sap which has a higher concentration of salts as compared to the outside soil water. This difference sets off osmosis and the outside water diffuses into the root hair.

Absorption of mineral elements:-

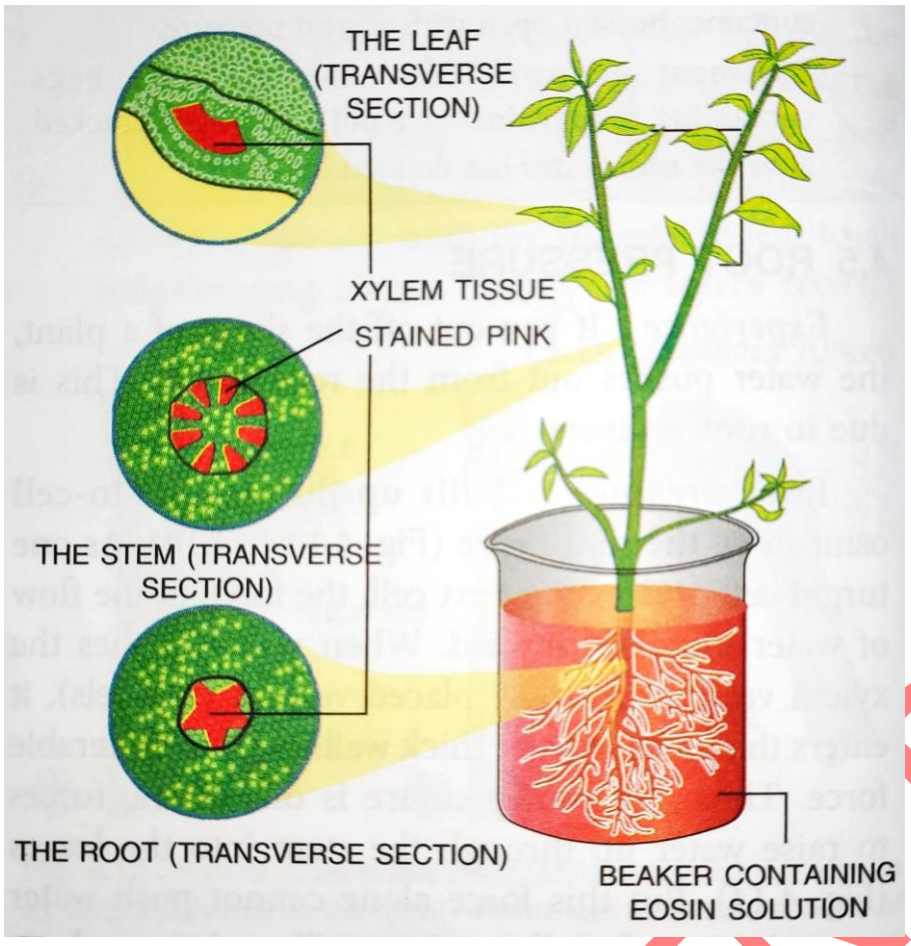
The soil involves active transport by the cells. Minerals may also be absorbed as ions rather than as salts. This upward flow occurs through the xylem.

SOME EXPERIMENTS ON ABSORPTION AND CONDUCTION OF WATER IN THE PLANTS

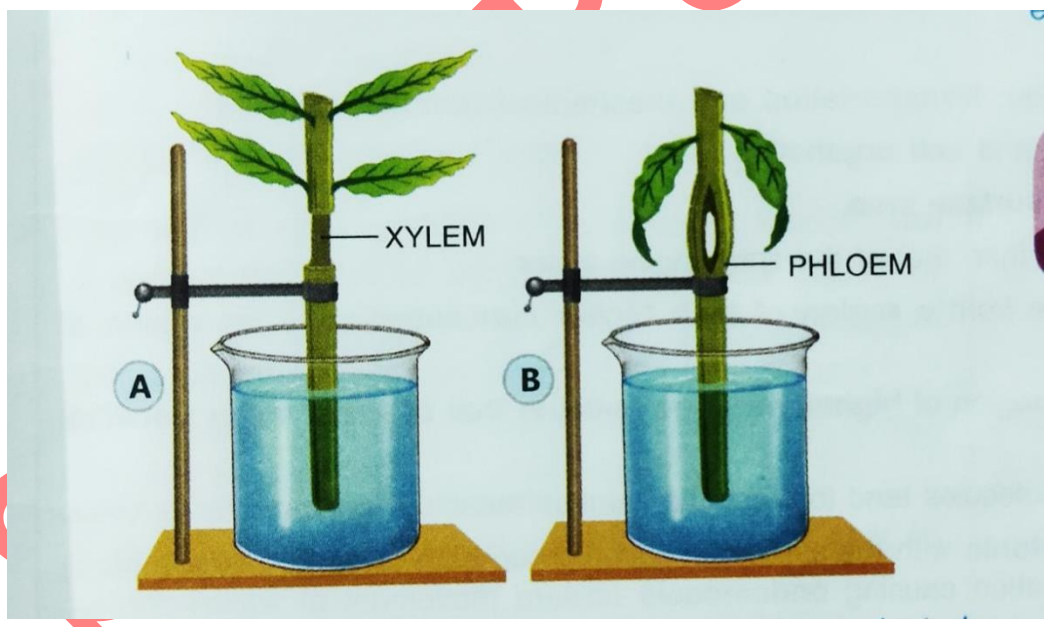
Experiment 1. To show that root absorbs water



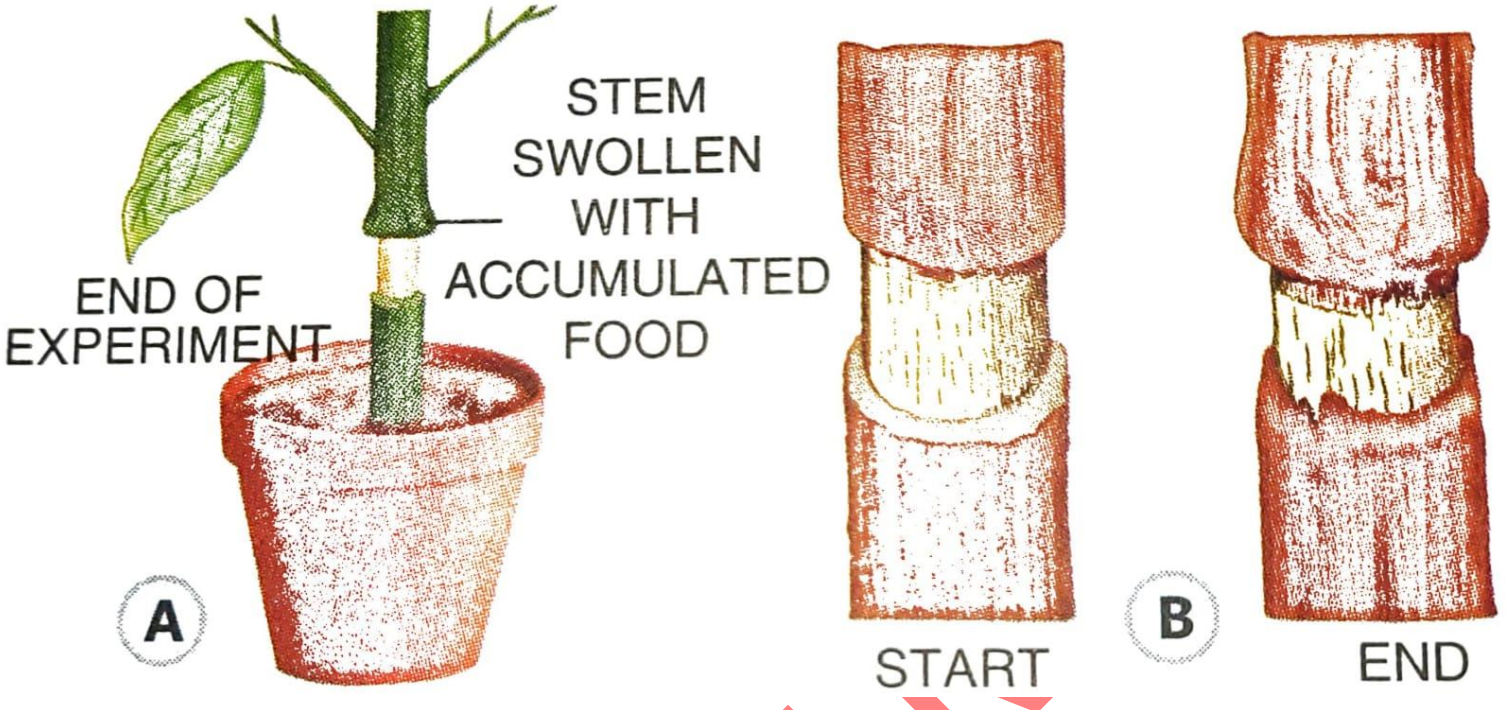
Experiment 2. **To show that water is conducted upwards through the xylem.**



Experiment 3. **Conduction of water through xylem**



Experiment 4. **To show that food from the leaves is conducted downwards through the phloem in the stem.**



FORCES CONTRIBUTING TO ASCENT OF SAP

There are four main forces which contribute to the upward movement (ascent) of sap.

1. Root pressure:- **Root pressure builds up sufficient force to push the sap in the xylem vessels up to a certain height and may be enough for herbaceous plants.**

2. Capillarity:- **Capillarity of xylem vessels causes the water from a lower level to rise to fill up the vacuum created by the loss of water due to transpiration from the leaves. Narrower the diameter of a tube, greater will be the height of water rising in it exerting a force called capillary force.**

3. Transpiration pull:- **As the water is lost from the leaf surface by transpiration, more water molecules are pulled up due to the**

tendency of water molecules to remain joined (cohesion), and thus to produce a continuous column of water through the stem.

4. Adhesion:- It causes the water to stick to the surface of cells thus drawing more water molecules from below when the leaf cells lose water during transpiration. This pulling force provided by the leaves is specially important in tall trees, such as pines, which do not have enough root pressure.